BAYESIAN HIDDEN MARKOV MODELS FOR SEGMENTATION OF GAIT MOTION CAPTURE DATA

E. Di Lello(1), A. Nieuwenhuys (2), K. Desloovere (3) and T. De Laet(4)
(1,4) KU Leuven, Dept. of Mechanical Engineering, Leuven, Belgium
(2,3) KU Leuven, Dept. of Rehabilitation Sciences , Leuven, Belgium

Main topics: 3DGA data, Cerebral Palsy

INTRODUCTION and AIM

The interpretation of 3DGA data often requires the segmentation of joint angle time-series (e.g. the identification of rockers in the ankle sagittal plane kinematics). We introduce a novel method for the automatic segmentation of joint angle time-series based on a Bayesian time-series model called Hierachical Dirichlet Process Hidden Markov Model (HDP-HMM) [1]. The goal of the method is to segment a joint angle time-series in a set of piecewise polynomial curves, while at the same time estimating the curve parameters and the time-correlation between the segments. The proposed method is suited for segmention of a set of time-series, (e.g. , a set of gait cycles exhibiting a specific pattern identified by a clinician) and to learn a probabilistic shape signature that can be used for classification of gait trials. Due to its Bayesian nature, the proposed method is able to incorporate clinical prior knowledge to produce a clinically meaningful segmentation.

PATIENTS/MATERIALS and METHODS

Our method is based on a Bayesian formulation. The goal of is HDP-HMM is to cluster the measurements in a set of possible polynomial segment models. Depending on the selected order of the polynomial, the method will try to split the observations in a number of lines, parabolic curves, etc. All the parameters of the model are defined through probability distributions, including the number of segment models. This means that if prior knowledge about the parameters is available, the HDP-HMM is able to incorporate it and combine with the data in a Bayesian way. To demonstrate the method, we use data of the sagittal plane ankle kinematics during stance, of 107 gait trial of children with CP. The gait trials were classified according to [1], so fivedifferent gait patterns are identified.

RESULTS

We used the proposed method to segment a single gait trial or a set of trials, using secondorder polynomial primitives.
Figure 1 presents a segmented trial belonging to class AStS 0 (minor deviations from normal), while Figure 2 presents an average segmentation of all the 66 trials of the class .
Figure 3 shows a segmented trial belonging to class AStS 1 (horizontal second rocker), while Figure 4 shows an average segmentation of all the 41 trials of the class.

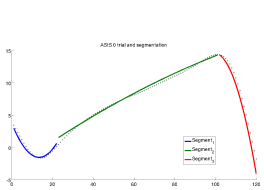
Fig.1 AStS_0 trial

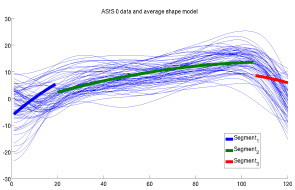
Fig2. AStS_0 shape model

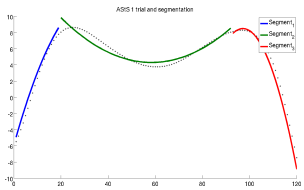
Fig.3 AStS_1 trial

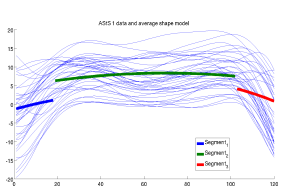
Fig.4 AStS_1 shape model

DISCUSSION and CONCLUSIONS

We showed how the proposed method is able to automatically segment gait trials using polynomial motion primitives. The HDP-HMM is able to capture the overall shape of a clinically relevant gait pattern. In the future, we plan to use these probabilistic shape models for classification of gait trials.

REFERENCES

[1] E.B. Fox et. al. PhD Thesis (2009)
[2] Van Gestel et al. *Res. Dev. Disabil* (2011)